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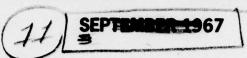
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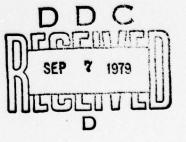
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AXIS-CROSSING GENERATOR (ACG),

10 to L.R/Weill and J. A/ Nesheim

San Diego, California



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403.023

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FOREWORD

This technical note describes the characteristics, operation and application of an electronic device called the Axis-Crossing Generator (ACG).

This memorandum has been prepared in the interest of others at NUWC and possibly a few persons or activities outside NUWC. It presents, for information, a small portion of the work being done in the area of sonar signal measurement and analysis.

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Page

Background	1
Introduction to the ACG	2
Functions of Major Components	3
Time Base Generator (TBG)	3
Ramp Trigger Pulse Generator (RTPG)	3
Fast Risetime Pulse Generator (FRPG)	4
Post-Ramp Offset Pulse Generator (PROPG)	4
Ramp Generator (RG)	4
Theory of Operation, Ramp Generator	4
Operator's Section	11
Preparation for Use	11
Operating Procedure	12

FIGURES	Page
Figure 1 ACG Block Diagram	6
Figure 2 Waveforms for PGAC	7
Figure 3 Waveforms for NGAC	8
Figure 4 Axis-Crossing Detector Error	9
Figure 5 Schematic, Ramp Generator	10
Figure 6 ACG Operational Connections Diagram	12
TABLES	
Table 1 Adjustments for 25 KC Operation	13
Table 2 Adjustments for 2.5 KC Operation	14
Table 3 Adjustments for 250 CPS Operation	15
Pable 4 Adjustments for 25 CPS Operation	16

BACKGROUND

Code D506 is investigating the usefulness of phase and amplitude characteristics of sonar signals, as measured on a cycle-by-cycle basis, for target detection and classification.

A Digital Axis-Crossing Interval Measurement System (DACIM) is being developed to measure zero axis crossing intervals and positive peak amplitude of signals between 0 and 25 KCPS. The digitized interval and amplitude information will be recorded on magnetic tape for subsequent analysis.

To check the performance of DACIM, it is necessary to have available, some representative sonar signals which have very accurately known axis crossing times. These signals are obtained by generating an axis-crossing ramp of predetermined slope from a fast risetime step. This memorandum describes a device which generates such a ramp.

INTRODUCTION to the AXIS-CROSSING GENERATOR (ACG)

The Axis Crossing Generator (see ACG Block Diagram Fig. 1), produces an output voltage which periodically passes from negative to positive values. Such a polarity shift we will call a positive-going axis crossing (PGAC). By means of a selector switch, negative-going axis crossings (NGAC) may also be produced. However, in the discussion which follows, we will consider only the PGAC, it being understood that what we say also applied to NGAC's.

The PGAC (Fig. 2) is a voltage ramp (actually the initial part of an RC charge waveform) which starts at -2 millivolts and rises through zero to a positive value. The ramp is generated by passing a voltage step through a simple RC integrator located in the RAMP GENERATOR chassis. The voltage step has a very fast risetime (on the order of 0.2 nanosecond), so that the time at which the step occurs is known precisely. This instant of time serves as a reference (t = 0) for the timing of events which follow. The time at which the ramp passes through zero (relative to the reference time t = 0), is known very accurately because the starting voltage of the ramp is small (-2 mv.) and the ramp slope is sufficiently steep to make component value deviations in the RC integrator insignificant. Note that only the timing of the PGAC relative to t = 0 is important. The time at which the PGAC occurs relative to some other time frame is unimportant. Knowing that the axis crossing occurs d nanoseconds after the step transition, we may then apply the ramp to the DACIM axis-crossing detector and note that the output of the detector occurs Y nanoseconds after the step transition. The quantity (Y - d) is the error of the axis-crossing detector (see Fig. 4, ACD error).

In addition to the basic function of generating PGAC's, the ACG has one refinement. Immediately prior to each PGAC, a negative half cycle of a

sine wave may be applied so that the axis crossing "appears" to be that of a sine wave. The period of the sine wave is the same as the interval between successive PGAC's. The amplitude of the wave form may be varied. The sine wave is applied to saturate the axis-crossing detector input transistors, thus testing for "memory effect" errors caused by stored base charge in these transistors. A sine wave was selected rather than a square wave because a sine wave is more representative of signals which would actually be encountered in using DACIM.

FUNCTIONS of MAJOR COMPONENTS

The major components of the ACG (see ACG Block Diagram, Fig. 1) are:

- (1) The Time Base Generator (TBG)
- (2) The Ramp Trigger Pulse Generator (RTPG)
- (3) The Fast-Rise Pulse Generator (FRPG)
- (4) The Post-Ramp Offset Pulse Generator (PROPG)
- (5) The Ramp Generator (RG)
- (1) <u>Time Base Generator</u> (TBG): The time base generator is an oscillator/square wave generator which clocks the entire sequence of events in the ACG.

 The period between successive PGAC's is controlled by this unit, and in addition, it provides the negative half cycle of the sine wave which precedes each PGAC. The TBG is a Wavetek model 105 signal generator.
- (2) Ramp Trigger Pulse Generator (RTPG): The RTPG, which is triggered by the TBG, provides a delayed pulse output which serves as a trigger for the Post-Ramp Offset Pulse Generator and the Fast-Rise Time Pulse Generator. The delayed output is required in order to obtain the proper time relationship between the pre-ramp sine wave and the ramp itself. The RTPG is an

Intercontinental Instrument Incorporated model PG-2 variable rise-time pulse generator.

- (3) <u>Fast-Risetime Pulse Generator</u> (FRPG): The FRPG is triggered by the RTPG to produce an extremely fast-risetime pulse (risetime is 0.2 nanosecond). The output of the FRPG is used to trigger the Ramp Generator and to act as a time reference (t = 0) for the measurement of the time at which a PGAC occurs. The FRPG is a Hewlett Packard model 213B pulse generator.
- (4) <u>Post-Ramp Offset Pulse Generator</u> (PROPG): The PROPG, triggered by the RTPG, assures that the output of the ramp generator remains positive following each PGAC. The PROPG is a Rutherford model 15B pulse generator.
- (5) The Ramp Generator (RG): The RG, when triggered by the FRPG, generates a ramp (the initial part of an RC charge curve). The slope of the ramp depends upon the RC time constant used. There are four different time constants available, each generated within its own separate RG chassis. The different time constants are for use at repetition frequencies of 25 cps, 250 cps, 2.5 kc, and 25 kc. The respective delays between the fast risetime step and the axis crossings for these four frequencies are 1530 ns, 153 ns, 15.3 ns, and 1.53 ns. The voltage level at which the ramp starts (-2 mv) is determined by an adjustable power supply, shown in the Block Diagram. The power supply is a Hewlett Packard model 721 A power supply.

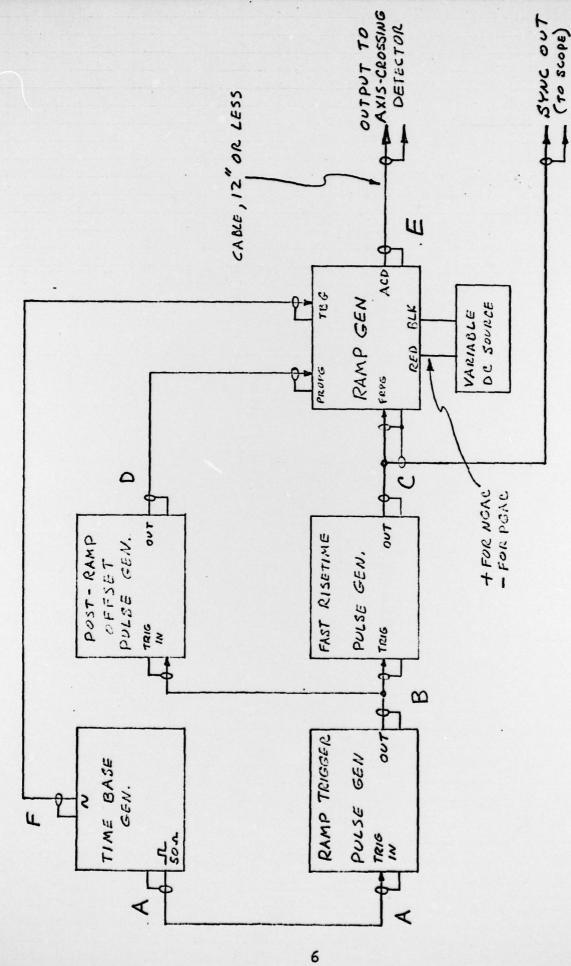
Figures 2 and 3 show the input/output waveforms for the major components of the ACG, when operating in the PGAC and NGAC modes of operation.

THEORY of OPERATION, RAMP GENERATOR

The Ramp Generator is the component from which the output of the ACG is taken. It forms its output by combining the signals from the FRPG, power supply, PROPG, and TBG. These signals are shown in proper time sequences for a PGAC in Figure 2. A schematic is shown in Figure 5.

Initially, the output signal is positive because of the positive signal from the PROPG. When the sine wave output of the TBG becomes negative relative to the output, the bias on the 1N914 diode changes from reverse to forward. This change effectively connects the output to the TBG so that the output signal is the same as the TBG signal. Through the voltage divider formed by R2, R3, and R4, the power supply adds a constant component of -2 mv. to the signals that form the output. As soon as the TBG signal becomes greater than this component voltage, the bias on the 1N914 becomes reversed again. This change causes the output to stay at -2 mv. Then the fast risetime pulse is initiated, which causes capacitor C1 to charge through R1. The exponentially rising voltage across C1 causes the output voltage to rise from -2 mv. through zero, thus generating an axis-crossing. At the conclusion of the FRPG pulse, the output voltage would decay back to -2 mv. if it were not for the positive signal from the PROPG. The end of the FRPG pulse and its subsequent decay concludes an ACG cycle.

Diodes CR3 and CR4 form a clamp that keeps Cl from being charged to an excessively high voltage when the sine wave is added to the ACG output. The PROPG input diodes form a gate that will not conduct until the PROPG signal has reached the diode threshold voltage. The PROPG signal is shown in Figure 2 to be zero on alternate half-cycles. Actually, the output circuitry of the PROPG causes the signal to be offset from zero by a small amount. Diodes CR1 and CR2 keep this residual voltage from interfering with the output of the RG respectively, for a PGAC and a NGAC. Each diode blocks the residual voltage because it cannot conduct until it is biased sufficiently in the forward direction to exceed its conducting threshold.



ACG BLOCK DIAGRAM

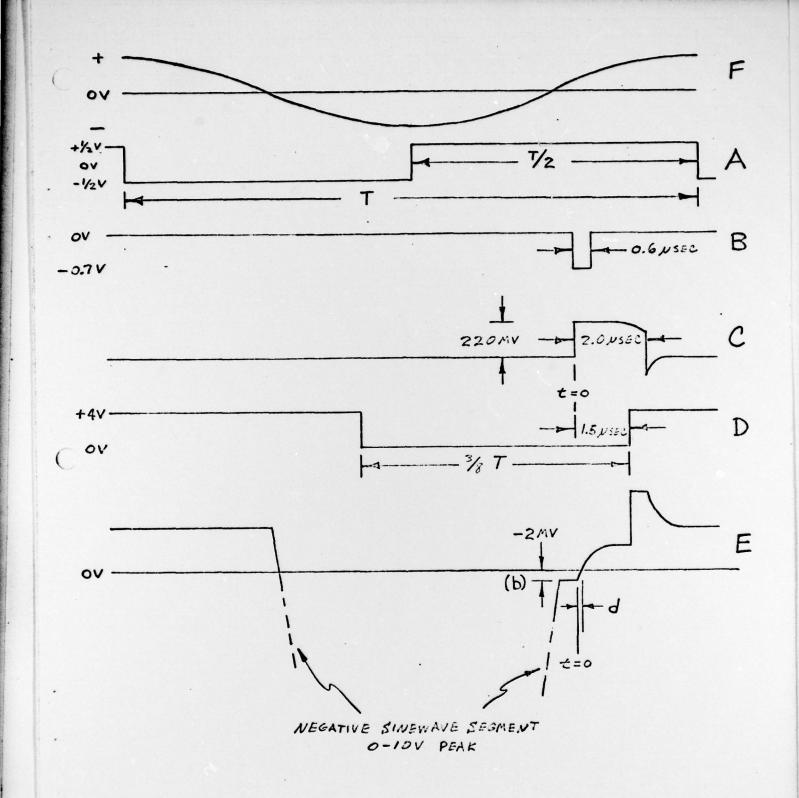
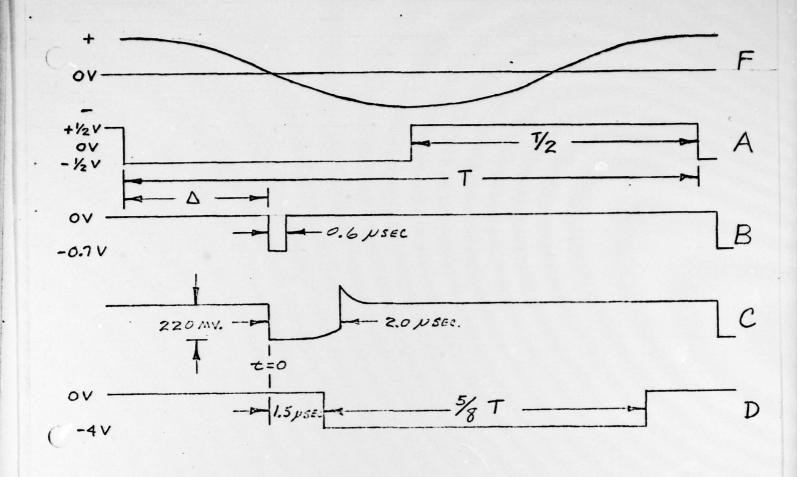


FIG. 2 WAVEFORMS FOR PGAC



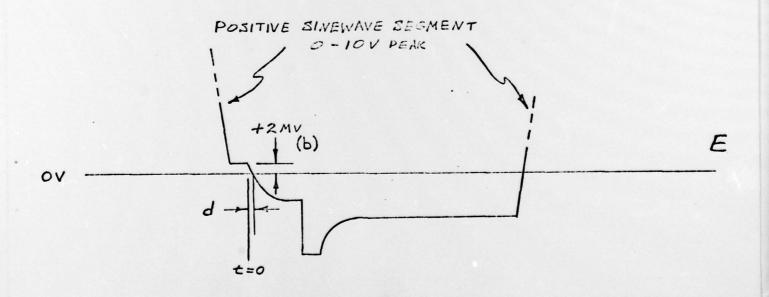
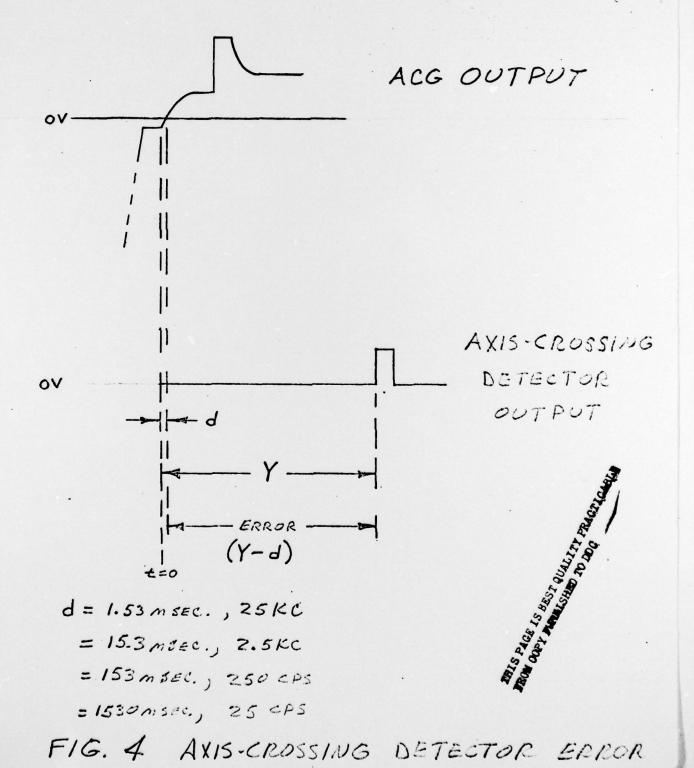


FIG. 3 WAVEFORMS FOR NGAC



33,000 pf 3,000 " Equivalent Sine Wave Freq. 25 cps 250 " 2500 " Ramp Gen. #

Note: Slight differences in resistor values may be noticed from unit to unit.

OPERATOR'S SECTION

PREPARATION for USE

First determine which of the 4 equivalent sine wave frequencies is to be used for a particular test; 25 kc, 2.5 kc, 250 cps, 25 cps. This will, in turn, determine which one of the four Ramp Generators to incorporate into the ACG.

Connect all major components of the ACG as per Figure 1 ACG Block
Diagram, using coaxial cable everywhere except for the Variable DC Source
connection, which can be "hook-up" wire. The cable connecting the Ramp
Generator and Axis-Crossing Detector should be short as possible and not
to exceed 12 inches in length.

Next, refer to the Adjustments Table which applies to the chosen equivalent sine wave frequency. Working from left to right across the table, make adjustments indicated in row 2, then row 3 and so on, using an oscilloscope when called for. Note that the upper half of each table applies to NGAC's and the lower half to PGAC's.

OPERATING PROCEDURE

After the ACG has been readied for use, connect it, using coaxial cable, to the Axis-Crossing Detector and Sampling Oscilloscope as shown in Figure 6.

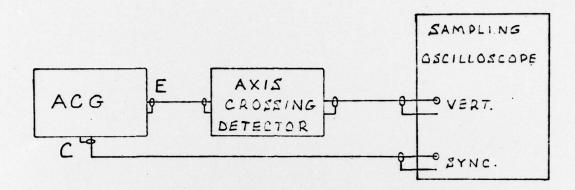


FIGURE 6 OPERATIONAL CONNECTIONS DIAGRAM

Observe the scope trace and measure the time Y from the beginning of the sweep to the leading edge of the Axis-Crossing Detector output pulse. This time represents the sum of the fixed time delay "d" inherent in the RG (different for each equivalent sine wave frequency) and the Axis-Crossing Detector error. Subtracting "d" from the quantity Y displayed on the scope yields the Axis-Crossing Detector error.

	MPLITURE	(NEGATIVE) PEAK	4.0 volts	50 A CUTHI AMPLITUTE			Maximum
	POLARITY SWITCH	(NECATIVE)	(NECATIVE	voc			
	PALLTIME	Minimur (10ns)	Minimum (10ns)	OUTPUT * AMPLITUDE			Adjust for desired test Minimum conditions
	RISETIME CONTROL	Minimum (10ns)	Minimum (10ns)	WAVEFORM OU			7
	NORMAL/COMP SWITCH "	NORMAL	NORMAL	Freq. CPS * WA (FERIOD)			25Kc (T = 40 w sec)
	DP/DELAY SWITCH	DEIAY	DETAY	PLIER			
	OFFSET SWITCH	OPF	OFF				XO CX
		0.6µsec. OFF	25 Jusec	AXIS-CROSSING DIRECTION SW		NGAC	
	FULSE DELAY FULSE (Δ) WIDTH	11 p sec.	1.5µ8ec.	* AD			
ing post	PREQUENCY *	Not Applicable	Not Applicable			+2.0 mv.	
to red binding post	SLOPE * FR	Maximum No Negative Ap	Maximum Not Fositive App	STEF INPUT		220 BV.	
		Adjust Max for stable Neg triggering	Adjust for Max stable Fos triggering	OUTPUT POLARITY SW.	NEG.		
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 B:	RAMP TRICCER FULSE GENERATOR	EXC/ MANUAL	+(Positive)	Adjust for stable triggering	Maximum Positive	Not Applicable	11µ sec.	0.6µsec. 0FF	OFF	DELAY	NORMAL	Minimum (10ns)	Minimum (10ns)	-(Negative)	-0.7 volts pk
	FULT-RAMP OFFERT PULSE GENERATOR	EXT/ MANUAL	+(Positive) Adjust for stable triggering	Adjust for stable triggering	Maximum Positive	Not Applicable	1.5 µ sec.	1.5 µ sec. 25 µ sec. OFF	OFF	IEIAY	NORWAL	Minimum (10ns)	Minimum (10ns)	+(Positive	+ 4.0 volts
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E .	FAST-RISE PULSE CENERATOR	NEC.	As required to get a stable output	ed POS.											
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1 2	A-P: TIME BASE CENERATOR								ACLOK.		25ke (T - 40 paec	b	Adjust for desired test conditions	Minimum) aximum
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NOTE: 1. Use Ramp Generator # h
2. Zero-Crossing delay time (d) is 1.53 ns.
3. * Check with Oscilloscore

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			H.	ä		ü		

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		OPERATING MODE SW.	TRIGGER SLOPE SW.	THRESHOLD *	SLOPE *	FREQUENCY	FREQUENCY * FULSE DELAY-FULSE (\(\Darksigma \) WIDTH	*	OFFSET SWITCH	DP/DRIAY Switch	NORMAL/COMP SATTCH	RISETIME	FALLTIME	FOLARITY SWITCH	AMPLITUIE . ADJUST
ä	RAVE TRIGGER EXT/ FULCE MANU GENERATOR	EXT/ MANUAL	+ (Positive) Adjust for stable triggering	Adjust for stable triggering	Maximum Positive	Mot	110 y sec.	0.6µ sec. OFF	097	DELAY	NOFOMAL	Minimum (10ns.)	Minimum (10ns.)	-(Negative)	-(Regative) -0.7 volts pk
ä	POST-RAND OFFICE FULSE SELENATOR	EXT/ MARUAL	+ (Positive) Adjust for stable triggering	Adjust for stable triggering	Maximum Positive	Not Applicable	1.5µ sec.	250 Weec. OFF	OFF	IEIAY	MORMAL	Minimum (10ns.)	Minimum (10ns.)	+(Positive)	+(Positive) +4.0 volts
		TRICGER FOLARITY SW.	TRICCER *	OUTPUT TY POLARITY SW	STEP	INPUT *	PRE-RAMP * ADJ OFFSET(b) ADJ D	AXIS-CROSSING DIRECTION SW.		IPLIER	Freq. CPS * WAVEFORM (FERIOD)		(INTER AC)	VCG 5	SO A CUTPUT AMPLITURE
ដ	FAST-RISE FULSE GENERATOR	NEC.	As required to get a stable output	ed POS.											
isi	PAMP CENERATOR				220 m	- 2.	- 2.0 mV. P	FGAC					•		
A-F:	TIME PASE CERENATOR								Ţ.	N E	2.5 Ke T = 400µ s.	7	Adjust for desired test conditions	Minimum	Maximum
	NOTE: 1. Use 2. Zer	1. Use RAMP Generator # 3	Use RAMP Generator # 3 Zero-Crossing delay time (d) is 15.3 ns.	1e 15.3 ns.								TAI	TABLE 2. ADJUS	ADJUSTMENTS FOR 2.5 KC OPPRATION	2.5 KC

NOTE: 1. Use RAND Cenerator # 3
2. Zero-Crossing delay time (d) is 15.3 ns.
3. * Measure with Oscilloscope

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ň	HAND TRIGGER EXXIVERS MANU GENERATOR	EXC/ MANUAL	- (Regative) Adjust for stable tring	Adjust for stable triggering	Maximum Negative	Not Applicable	1.1 ms.	0.6 µ8ec	OFF	DELAY	NOHWAL	Minimum (10ns.)	Minimum (10ns.)	-(Regative)	-0.7 volts pk
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5	PAST-FICE PULSE GENERATOR	NEC.	As required to get a stable output	d NEG put											
ŭ	RAMP CENERATOR				220 mV.		+ 2.0 BK.	NGAC							
A-F:	TIME IMIES								x 100		250 CPS T = 4 ms.	Added	Adjust for desired test conditions	Minimum	Maximum

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PEMC + Output of Variable-V source goes to black binding post. ORNOWTHNO TRICKER SHORTTYTY SENSITIVITY SENSITIVITY SENSITIVITY SENSITIVITY SENSITIVITY SENSITIVITY SENSITIVITY STEP INFO. 2.5 ms. OFF DELAY NORMAL TRICKERING TRICKER NORMAL TRICKERING TRICKER NORMAL TRICKER TO TRICKER TRICKER THE TRICKER				Minimum (10ns.)	Minimum (10ms.)				
PEMC + Output of Variable-V source goes to black binding post. ORNATING TRICKER WALTAL HOST SHORTTVITY SENSITIVITY SENSITIV			NORMAL/COMP SWITCH	NORMAL	NORMAL	Freq. CPS * W. (PERIOD)			250 CPS
PEAC + Output of Variable-V source goes to bla OPENTING TRICKER THRESHOLD * SIGHE * NOIE SW SLOIE SW. SENSITIVITY SENSITIVITY SET / + (Positive) Adjust for Maximum stable triggering triggering triggering tributive triggering triggering trickering trickering trickering to STEP (STARITY SW MASHET SENSITIVITY STEP (STARITY SW MASHET SENSITIVITY STABLE TO SENSITIVITY STEP (STARITY SW MASHET SENSITIVITY STABLE STABLE OUTPUT STEP (STARITY SW MASHET STABLE OUTPUT STEP)		•	DP/DEIAY SWITCH	DELAY	DELAY	IPLIER			
PEAC + Output of Variable-V source goes to bla OFFANTING TRICKER THRESHOLD * SIGHE * NOIS SW SLOIE SW. SENSITIVITY SENSITIVITY SET / + (Positive) Adjust for Maximum stable triggering to stable to stable to stable to set a stable output to get a stable output to set a stable output to set a stable output 220 m			PFSET WITCH	FF	FF	MUL			¥.
PEAC + Output of Variable-V source goes to bla OFFANTING TRICKER THRESHOLD * SIGHE * NOIS SW SLOIE SW. SENSITIVITY SENSITIVITY SET / + (Positive) Adjust for Maximum stable triggering to stable to stable to stable to set a stable output to get a stable output to set a stable output to set a stable output 220 m			VICTOR * C	0.6 wsec	2,5 ms. C	IS-CROSSING RECTION SW.		10	
PEAC + Output of Variable-V source goes to bla OFFANTING TRICKER THRESHOLD * SIGHE * NOIS SW SLOIE SW. SENSITIVITY SENSITIVITY SET / + (Positive) Adjust for Maximum stable triggering to stable to stable to stable to set a stable output to get a stable output to set a stable output to set a stable output 220 m		X	PULSE DELAY	1.1 ms.	1.5µ sec.	* 73			
PEAC + Output of Variable-V source goes to bla OFFANTING TRICKER THRESHOLD * SIGHE * NOIS SW SLOIE SW. SENSITIVITY SENSITIVITY SET / + (Positive) Adjust for Maximum stable triggering to stable to stable to stable to set a stable output to get a stable output to set a stable output to set a stable output 220 m		inding post	QUENCY .	licable	licable			-2.0 m	
PEAC + OPPEATING NOIS SM GER EXT/ NAUTAL SMIT/ ICE MARUAL PPICOER POLARITY SE RED.		to black b	FIG.	8)		STEP INFU		220 mV.	
PEAC + OPPEATING NOIS SM GER EXT/ NAUTAL SMIT/ ICE MARUAL PPICOER POLARITY SE RED.		goes	STOIT	Maxim	Maxin Posit	8			
PEAC + OPPEAUTING NOIS SM GER EXT/ NAUTAL SMT/ ICE MARUAL FOLARITY SR REJ,		le-V source	HRECHOLD .	djust for table riggering	djust for table riegering	OUTIVE FOLARETY	105.		
PEAC + OPPEATING NOIS SM GER EXT/ NAUTAL SMIT/ ICE MARUAL PPICOER POLARITY SE RED.		tput of Wariab	TOTE SW. S	· (Positive) A	· (Positive) A	TRIGGER *	As required to get a stable outpu		
B: BAME TRICOER FULGE CHICALO D: POST-RUMP CHICALOUP CHI				VI.	EXT/ Manual	TRICCER FOLARITY SW	MBS.		
ii				PAMP TRICCER FULCE CENERATOR	POST-RAMP OPTIGHT PULCE CERTEMATOR		Fast-Rise Fase Generator	ramp Cenerator	TINE BASE CRIERATOR
	-			:: ::	ä		ij	<u>ii</u>	A-P:

NOTE: 1. Use BANT Generator # 2 2. Zero-Crossing delay time (d) is 153 ns 3. • Check with Oscilloscope

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15

TABLE 3. ADJUSTMENTS FOR 250 CPS OFFICENTION

	HOAC +	Output of Var	NAME + Output of Wariable-V source goes to red	goes to rec		et.				The state of the s	Section 1	chemin 1	AMARIA ESS	A CANTON TOTAL
	OPERATING MODE SW.	TRICCER SLOPE SW.	THRESHOLD *	SLOPE *	FREQUENCY	FREQUENCY * PULSE DELAY* PULSE * (\(\Delta \) \(\text{VIDITH} \)		OFFSET SWITCH	DP/DELAY SWITCH	NOIGNAL/ COMP SWITCH	CONTROL	CONTROL	SWITTCH	ALMUST
RAMP TRICGER EXT/ RILSE MARIU GERGERATOR	R EXT/ NAUTUAL	- (Negative)	Adjust for stable triggering	Maximum Negative	Not Applicable	11.0 ms.	0.6 µ sec UFF		DELAY	NORMAD	Minimum (10ns.)	Minimum (10ms.)	-(Negative)	-0.7 volts pk
POST-RAMP OFFSET PULSE GENERATOR	EXT/ NAMUAL	+ (Positive) Adjust for stable triggering	Adjust for stable triggering	Maximum Positive	Not Applicable	1.5,48	25 ms C	OFF	DELAY	NORMAL	Minimum (10ns.)	Minimum (10ng.)	-(Negativė	-(Negativy -4.0 volts
	TRIGGER	TRICGER * SENSITIVITY	* OUTHUT TY POLARITY SW.	STEP	* .	PRE-RAMP OFFSET(b) ADJ	AXIS-CROSSING DIRECTION		DIAL MUTIPLIER (F	Freq. CPS* W. (FERIOD)	WAVEFORM (I	(INTER AC) OUTHUR AMPLITURE *	VOG	SO A CUTINITIAN
PAST-RISE PULCE GENERATOR	NBC.	As required to get a stable ouput	ed MEG.											
NAMP CENERATOR				220 mV.		+ 2.0 mV.	NGAC							
A-F: TIME BACE GENERATOR							•	x 1000		25 CPS	A S S	Adjust for desired test conditions	Minimum	Maximum
	-	1				1								

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-		-		-				75 TE 10 TE
	AMPLITUDE * ADJUST	-(Negative -0.7 volts pk	+4.0 volts	SO A CUTATOR			was a second	25 038
	POLARITY SWITCH	-(Negative	+(Fositive	VCC			Minimum M	USTMENTS FOR
	FALLTDE	Minimum (10ns.)	Minimum (10ms.)	(INTER AC) OUTPUT AMPLITUDE			Adjust for desired test conditions	TABLE 4. ADJUSTMENTS FOR 25 CIPS OFFICE OFFI
	RISETIME	Minimum (10ns.)	Minimum (10ns.)	WAVEFORM (1)			7	A
	NORMAL/COMP SWITCH	NORMAL	NORMAL	Freq. CPS * W. (PERIOD)			25 CPS T = 40 ms	
	DP/DELAY SATTCH	IEIAY	DELAY	IPLER				
	OFFSET	OFF	OFF	DIAL			X 1000	
	PULSE *	0.6 wsec OFF	25 ms	AXIS CROSSING DIRECTION		10		
	PULGE DELAY	11.0 ms	1.5 y sec	AD		mv. FGAC		
binding nos	FREQUENCY *	Not Applicable	Not Applicable	*		- 2.0 mV.	-	
Trie + Cutwit of Wartable-V scurce sees to black binding rost	SIOPE * F	Maximum N Positive A		STEP INTO		220 m <.		53 11800
on annua V-a	THRESHOLD * SI SENSITIVITY SI			OUTPUT POLARITY SW	FOS,			1 200 000 1
Medanda A	TRICGER THE	+ (Positive) Adjust for stable triggering	(Positive) Adjust for stable triggering	TRICGER *	As required to get a stable output			or # 1
100	OFFRATING THE MODE SW SLO	EXT/ + (EXT/ + (TRICGER FOLANITY SW	PUS.			NCTE: 1. Use NAW Cenerator # 1
		RAME TRICGER PULCE GENERATOR	POST-RAMP OFFSET PULSE GENERATOR		FACT-RISE PULCE CENERATOR	PAMP CENTERATOR	A-P: TDE MOB GERMATOR	NOTE: 1. Use
L		នំ	::		ย	äi	A-F:	

1. Use MAW Generator # 1 2. Zero-Tronsing delay time (d) is 1530 ns = 1.53 psec 3. * Measure with Oscilloscope NOTE:

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